

# (12) UK Patent Application (19) GB (11) 2 298 483 (13) A

(43) Date of Printing by UK Office 04.09.1996

(21) Application No 9607368.9

(22) Date of Filing 07.10.1994

(30) Priority Data

(31) 9320637

(32) 07.10.1993

(33) GB

(86) International Application Data

PCT/GB94/02188 En 07.10.1994

(87) International Publication Data

WO95/10057 En 13.04.1995

(71) Applicant(s)

Peter Frederick Bradbeer  
50 Hag Hill Rise, TAPLOW NR MAIDENHEAD,  
Berkshire, SL6 0CT, United Kingdom

(72) Inventor(s)

Peter Frederick Bradbeer

(74) Agent and/or Address for Service

F J Cleveland & Co  
40-43 Chancery Lane, LONDON, WC2A 1JQ,  
United Kingdom

(51) INT CL<sup>6</sup>

G01V 8/12

(52) UK CL (Edition O )

G1A AG17 AG6 AG9 AMQX AR6 AR7 AT21 AT27 AT3  
U1S S1872

(56) Documents Cited by ISA

JP 590193382 A US 5032716 A US 5012086 A

US 4973873 A US 4339660 A

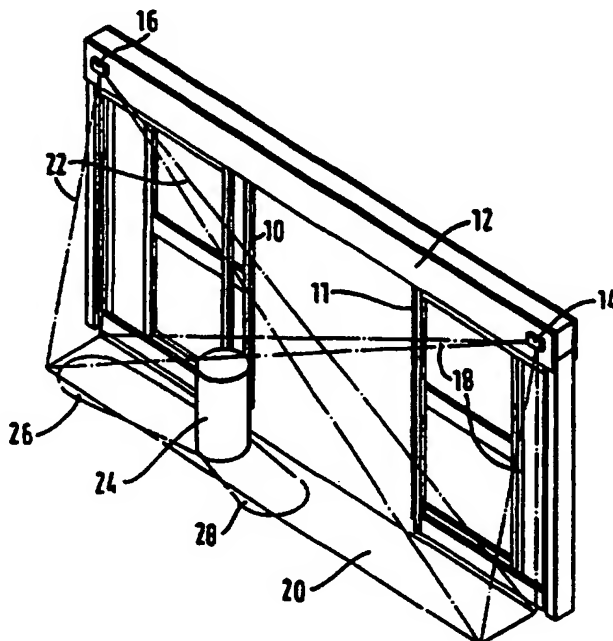
PATENT ABSTRACTS OF JAPAN, Vol 9, No 58, (p-341)  
(1781) 14 March 1985

(58) Field of Search by ISA

INT CL<sup>6</sup> F16P, G01V, G08B, G08G

(54) Proximity detectors

(57) A proximity detection system for detecting the presence of an object in a given zone or area comprises a transmitter (14) arranged to illuminate that zone (20) and a receiver (16) arranged to receive illumination reflected from that zone (20). The transmitter (14) and detector (16) are arranged such that the presence of an object (24) in the zone (20) results in a decrease in the strength of the signal reflected to the receiver (16). This is because the object (24) casts a shadow (26) in the illumination from the transmitter (14) and the strength of the receiver signal is further reduced by the object (24) preventing transmitted light reflected from a second area (28) from reaching the receiver (16). In one embodiment polarising means are provided to polarise the received and transmitted illumination in substantially orthogonal planes.



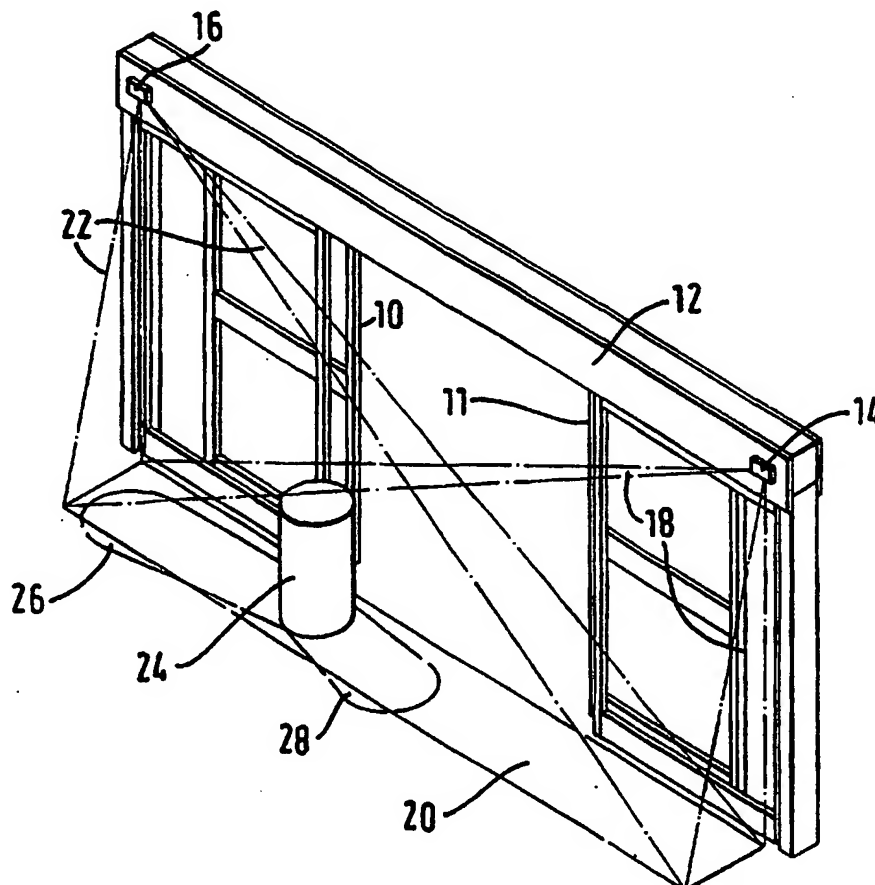
GB 2 298 483 A

## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup>:</b>  <b>G01V 8/12</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 95/10057</b>  <b>(43) International Publication Date:</b> 13 April 1995 (13.04.95)
<b>(21) International Application Number:</b> PCT/GB94/02188  <b>(22) International Filing Date:</b> 7 October 1994 (07.10.94)  <b>(30) Priority Data:</b> 9320637.3      7 October 1993 (07.10.93)      GB  <b>(71)(72) Applicant and Inventor:</b> BRADBEER, Peter, Frederick [GB/GB]; 50 Hag Hill Rise, Taplow Nr. Maidenhead, Berkshire SL6 0CT (GB).  <b>(74) Agent:</b> SMITH, Norman, Ian; F.J. Cleveland & Company, 40- 43 Chancery Lane, London WC2A 1JQ (GB).		<b>(81) Designated States:</b> AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, KZ, LK, LU, LV, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.          Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

**(54) Title:** PROXIMITY DETECTORS**(57) Abstract**

A proximity detection system for detecting the presence of an object in a given zone or area comprises a transmitter (14) arranged to illuminate that zone (20) and a receiver (16) arranged to receive illumination reflected from that zone (20). The transmitter (14) and detector (16) are arranged such that the presence of an object (24) in the zone (20) results in a decrease in the strength of the signal reflected to the receiver (16). This is because the object (24) casts a shadow (26) in the illumination from the transmitter (14) and the strength of the receiver signal is further reduced by the object (24) preventing transmitted light reflected from a second area (28) from reaching the receiver (16). In one embodiment polarising means are provided to polarise the received and transmitted illumination in substantially orthogonal planes.



**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgyzstan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

- 1 -

PROXIMITY DETECTORS

5        This invention relates to proximity  
detectors which detect the presence of an object,  
typically a human being, in a given zone or area. The  
invention has particular, but by no means exclusive,  
application to detecting the presence of a human being  
in the vicinity of automatically operable doors.

10        There are a number of safety problems  
associated with automatically operable doors which are  
in use in large numbers within many public buildings.  
The doors can be the sliding type, swing type, rotary  
15       type, or bi-folding type. The main difficulty  
concerns the use of microwave motion detectors to  
actuate the automatic door operator to allow the  
passage of traffic through the door. Whilst such a  
motion detector is adequate as an actuator it is not  
20       possible to detect a totally stationary object with  
this kind of motion detector. This can present a  
safety hazard in that if a person is close to the  
automatic door and the doors are in an open position  
and if the movement of that person is insufficient to  
25       trigger the motion detector then it is possible that  
the doors may close possibly startling, crushing or  
trapping the person between the doors. To alleviate  
this problem it has been common to use a photoelectric  
detector which is mounted on the frame of the door and  
30       projects a pencil-thin beam across the face of the  
door. Whilst this beam is sufficient to detect the  
presence of a person actually between the doors, since  
it is necessary to break the beam, it is not possible  
to detect a person in very close proximity to the door

- 2 -

when a person is in such a position so as not to break the beam. The problem can be further accentuated if that person is using a walking frame for example. The walking frame may not break the beam and the doors may therefore close trapping the walking frame which can destabilise the person who is using the frame. It is therefore highly desirable to provide a presence detector which works within, for example, 16 inches either side of the door. The proximity detector should provide a sensitive area within which the presence of a person, whether stationary or not, will cause the doors to remain in the open position until the zone is cleared on both sides.

A number of devices have been proposed and one example is described in Stanley Patent No. 4823010. This describes a proximity detector for use with automatic sliding doors. Whilst this detector does provide a measure of increased safety to the users of automatic doors it does not however provide detection coverage all the way to the floor. Its sensitivity is also dependent somewhat on the reflectivity of the floor over which the detector is positioned. The detector is also very sensitive to the reflectivity of the object, it being less sensitive to less reflective objects. This detector is also insensitive when the area of the object to be detected is very small, such as in the case of small adults or small children, wherein particular the area presented to the detector (that is the plan view of the person) is a small area. This can be further accentuated if the hair colouring is dark or the clothing is dark.

- 3 -

In addition the Stanley device is rendered inoperative when the doors have started to close. This is necessary because the plane of the door intersects the sensitive area.

5

Prior art detectors have been based on a number of different physical phenomena and use a number of detection media, e.g. microwave, ultrasonic, passive infra-red and active infra-red. For short range use (20 feet or less) active infra-red offers a number of advantages not least of which is small-sized, low cost and relatively high noise immunity. When using infra-red it is common to employ a retro-reflective arrangement, whereby infra-red radiation from the transmitter is reflected off the surface of the object to be detected and is then measured by the receiver. When the received signal is greater than a predetermined threshold the control signal is given to indicate that an object has been detected. When using this kind of detector to detect people, for example, a major disadvantage becomes apparent in that the detection range of the detector is dependent to a large degree on the reflectivity (at the transmitted wavelength) of the object to be detected. In the case of collision avoidance systems, which may be associated with moving vehicles or machinery such as automatic doors, this can be a major disadvantage. As a simple example consider the case where the minimum detection range is say 2 feet. It would therefore be necessary to set the sensitivity of the detector to a level that ensures that the least reflective object (e.g. matt black) is detected at a range of 2 feet. Such a sensitivity point would mean that a highly reflective object (say 10 times more

- 4 -

reflective than matt black) would be detected at over 6 feet. This can in many cases present severe operational difficulties.

5           In the above it has been assumed that the  
projected illumination from the transmitter forms an  
illuminated pool smaller than the object to be  
detected. Provided that this condition is met  
increases in the surface area of the object to be  
10 detected will not increase the detection range of the  
device. If the above condition is not met, however,  
as will be the case whenever the detection field is  
required to extend far beyond the dimensions of the  
object to be detected, then the detection range will  
15 be affected by the surface area of the reflecting  
object.

          U.S. Patent No. 4,973,837 describes a  
proximity detector arrangement that suffers to some  
20 extent from this undesirable characteristic, although  
some methods of improvement are described. The  
document describes a proximity detector that is  
mounted at a height of typically 7 feet 6 inches and  
projects a detection zone downwards towards the floor,  
25 the dimensions of that detection zone being defined by  
a mask. For simplicity this type of detector will be  
referred to as being retro-reflective and having a  
geometrically determined range. Whilst this type of  
retro-reflective detector does accurately provide a  
30 detection field that is largely independent of the  
object's size and reflectivity, this immunity is  
achieved by providing a high degree of sensitivity  
within the geometrically determined range. The  
sensitivity needs to be high enough to detect the

- 5 -

smallest expected surface area having the least reflective surface at the furthest point of the detection field. There are some practical disadvantages of having such a high degree of sensitivity since the detector, in the absence of a person is looking at the illuminated portion of the floor and becomes sensitive to relatively small changes in the surface reflectivity of that floor. Such changes can be brought about by, for example, the displacement of a floor mat or the wetting of the floor.

It is an object of the present invention to provide a proximity detector that has an accurately defined range and is largely immune to variations in the object's surface area and reflectivity whilst also being relatively insensitive to temporal changes in the floor reflectivity or similar surfaces (e.g. ceiling wall etc. if the radiation is reflected from them). The present detector can be used as a presence detector, a motion detector or both.

According to one aspect of the present invention there is provided a proximity detector comprising a transmitter for transmitting a beam of radiation into a preselected area or zone, a receiver for receiving radiation from that zone, the transmitter and receiver being spaced apart and so located relative to said zone that the transmitter transmits a beam of radiation of predetermined shape into the area from where it is reflected into the receiver, the relative dispositions of the transmitter and receiver being such that when an object is present in the zone a shadow is effectively cast on either



- 6 -

side of the object to thereby cause a fall in the level of reflected radiation received at the receiver.

5           The detector may include control circuitry responsive to the received signals for providing actuating signals for controlling, for example, automatically operable doors. The control circuitry may include any one or more of the following. Means  
10   for avoiding interference between a number of similar detectors operating in close proximity to one another. Means providing relatively high immunity to interfering signals such as broad band infra-red emission from fluorescent lighting, mains hum, radio  
15   signals and intense sunlight. Means for providing high immunity to changes in the effective sensitivity of silicon photo diodes due to high intensity ambient light. Means for providing high immunity against temperature drift of receivers and transmitters.  
20   Means for providing automatic compensation for background reflectivity levels. Temporal variations in background reflectivity levels. A means for providing an automatically initiatable rapid reset if detection of an object is continuous for greater than  
25   a predetermined period of time. Means for providing an audible or visual announcement prior to the rapid reset facility.

30           A feature of the present detector is that it is relatively insensitive to variations in area, reflectivity or colour of the object and hence represents an enhancement on the prior art. It can be used in addition to known motion detectors or can

- 7 -

itself be used in association with appropriate control circuitry to provide the motion detection.

Another aspect of the present invention  
5 relates to the operation of a proximity detector in situations where the reflecting surface, e.g. a floor, is damp or wet. Such condition can produce specular reflections and this can affect the operation of the detector. I have found that the problem of specular  
10 reflection can be alleviated by using polarising means for polarising the radiation.

Thus according to another aspect of the invention there is provided a proximity detector of  
15 the type in which a transmitter transmits radiation into zone or zones and a receiver detects radiation received from the zone to provide actuating signals for actuating apparatus such as automatically operable doors, wherein a polarising means for polarising the  
20 radiation is associated with at least one of the transmitter and receiver. The polarising means is preferably associated with both the transmitter and the receiving and the polarising means is also preferably arranged to function as a crossed  
25 polariser.

The invention will be described now by way of example only, with particular reference to the accompanying drawings. In the drawings:

30

Figure 1 is a schematic view showing automatically operable doors equipped with a proximity detector in accordance with the present invention;

- 8 -

Figures 2A and 2B show control circuitry for use with the detector of Figure 1;

5 Figure 3 is a schematic view showing an alternative form of proximity detector, and

Figures 4 and 5 illustrate the operation of the detector.

10 Referring to Figure 1 a pair of automatically operable sliding doors (10, 11) are mounted in a frame (12). A proximity detector has a transmitter (14) which is mounted at one top corner of the frame (12) and a receiver (16) which is mounted at  
15 the opposite top corner. The transmitter (14) transmits a beam (18) of radiation, e.g. infra-red or near infra-red into a narrow zone (20) and the receiver can receive radiation reflected from that zone as shown by the reception beam (22). A similar  
20 transmitter and receiver arrangement is mounted on the opposite side of the door frame. The transmitter and/or receiver can have their transmitting or receiving field constrained to form the beam shapes shown in Figure 1 by means of a masking arrangement of  
25 the type described in US-A-4973837.

When an object as exemplified by the cylinder (24) in Figure 1 is present in the zone (20) a shadow (26, 28) is cast on either side of that  
30 object. Shadow (26) is caused by the object obstructing radiation transmitted from the transmitter and shadow (28) is caused by the object obstructing radiation reflected from the zone (20). It will be

- 9 -

seen that the size of the shadow is significantly greater than the upper surface of the object.

5 In this way the increase in the received  
signal strength due to transmitted energy reflected  
from the object's horizontal surface is very small  
compared with the decrease in received signals  
strength caused by the object's shadow as a result of  
the vertical surface area it presents to the  
10 transmitted wave front from the transmitter unit.

Besides the shading effect, the receiver has  
a portion of its field of view obscured by the object  
causing a further reduction in the received signal by  
15 virtue of the presence of the object within the  
sensitive area. Hence the presence of the object  
results in a significant decrease in the received  
signal.

20 It should be noted that the area of the  
shadow and the area of the obscured region is a  
function of the geometric relationships and positions  
of the objects to be detected and the transmitter and  
receiver units, as well as the areas of shadow and  
25 obscuration as compared to the reflectivity and  
reflective area of the object the greater is the  
attenuation of the total received energy at the  
receiver.

30 Generally the more statesque the object is  
and the greater its dimensions in the Z plane,  
relative to it's horizontal surface area, the greater  
is its attenuating effect and hence the easier it is  
to detect. For any particular application of the

- 10 -

technique and relative dimensions of the objects to be detected should be considered and the positioning and spacing of the units should be controlled accordingly so that a sufficient attenuation of the received energy signal by virtue of the object's presence within the prescribed detection zone is ensured, thus maximising the probability of the object being detected.

10                   The following are benefits of the present arrangement compared with conventional retroreflective techniques.

15                   1) The object's colour or reflectivity is of very little practical significance. Only it's opacity at the operating wavelength of the detector is significant.

20                   2) The detector is inherently sensitive to objects that can cast shadows. Thus objects with some element of height as depicted in Figure 1 for example are most suitable. This type of detector is ideally suited to detecting upright people for example.

25                   3) The detector has inherently good discrimination capabilities between even relatively small objects and changes in background reflection caused by, for instance the movement of a floor mat or wetting of the floor by water, when compared with its  
30                   retroreflective counterparts.

Although the embodiment is described using near infra-red wavelengths, such as are provided by infra-red LED's, it will be readily appreciated by a

- 11 -

person skilled in the art that other wavelengths of light or even ultrasound and microwaves could readily be used.

5                   By way of example only, a suitable signal processing system and detection system will now be described.

10                   The detection circuit has been designed to provide the following features:

1) A means of avoiding interference between a number of similar detectors operating in close proximity to one another.

15                   2) High immunity to interfering signals such as broad band infra-red emission from fluorescent lighting, mains hum, radio signals and intense sunlight.

20                   3) High immunity to changes in the effective sensitivity of silicon photo diodes due to high intensity ambient light.

25                   4) High immunity against temperature drift or receivers and transmitters.

30                   5) Automatic compensation for background reflectivity levels (self setting to site conditions).

6) Automatic adjustment to ongoing temporal variations in background reflectivity levels provided that these occur below a pre-set rate of change.

- 12 -

7) An automatically initiated rapid reset if detection of an object is continuous for greater than a predetermined period of time.

5           8) A means to initiate an audible or visual announcement prior to the reset action described in 7) above.

10           The circuit operation will now be described with reference to the schematic block diagram shown in Figure 2.

15           As a means to provide feature 1) above the circuit has a window comparator (50) which has its threshold voltages within a few hundred millivolts above and below 0 volts respectively. A signal  
20           derived from the mains voltage is AC coupled and low pass filtered at (52) to remove noise and then fed to the window comparator. The output of OR gate (54) is thus a short pulse occurring around the zero crossing points of the mains wave form. These pulses are fed to the reset inputs of both a binary counter (56) and octal counter (58). The binary counter (56) is  
25           clocked by a free running oscillator. The transmitter carrier frequency can be derived from the Q2 binary output of the counter (56) and the transmitter envelope signal rate may be chosen, for instance, to be one eighth of that frequency and so may be derived from the Q5 counter output. The output Q5 is then  
30           used to clock the octal counter (58). The outputs of the octal counter Q0 to Q7 inclusively mark sequential and equal time periods following each mains supply waveform zero crossing points. The octal counter output Q7 is connected to the clock inhibit input of

- 13 -

the octal counter and so the counter will only sequence once between each zero crossing.

5       The output Q0 in this example has been  
chosen to initiate a reference measurement via an  
analogue switch SW2, to be described further below.  
Thus any one of outputs Q1 through Q6 inclusively may  
be used to define a uniquely positioned carrier  
envelope by gating the selected output with the  
10      carrier frequency via an AND gate (60). In this way a  
number of similar systems may be operated in close  
proximity without mutual interference and without  
requiring an electrical connection between them. The  
only requirement is that their carrier envelopes are  
15      derived from different outputs on their respective  
octal counters. It can be seen that this arrangement  
provides six unique time windows within which  
transmission (and receiver measurements) may occur.  
The free running oscillator should have a broadly  
20      similar frequency.

As a means to provide feature 2) above  
immunity to interfering signals is achieved by the  
use of synchronous rectification. A synchronous  
25      rectifier (64) has a carrier input reference signal  
fed to it on line 66 as well as the amplified received  
signal on line 68. The output of the synchronous  
rectifier is thus a full wave synchronously rectified  
signal which is fed to analogue switches SW1 and SW2.  
30      Immunity is provided by the band width narrowing  
effect of the synchronous rectifier in conjunction  
with two low pass filters (70, 72). The low pass  
filter (70) outputs a DC level which is proportional  
to the amplitude of the received signal from the main



- 14 -

transmitter. The other low pass filter (72) which is connected to the output of an error amplifier (74) is used to provide both bandwidth narrowing of the received signal from the reference transmitter and  
5 also to provide some loop damping for the gain control loop. The function of this gain control loop will be described below.

As a means to provide feature 3) and 4) the  
10 receiver uses silicon photodiodes. Silicon photodiodes exhibit a change in effective sensitivity when subjected to high levels of background illumination such as may be caused by, for instance, sunlight or incandescent light. Generally the  
15 sentivity increases by a few percent but the actual level of change is dependent upon the intensity of the background light falling on the receiver. Since the detector measures small changes in received signals it is necessary to compensate for this change in receiver  
20 gain with a simple mechanism. The technique chosen here operates as follows:

The output of the synchronous rectifier (64) is time division de-multiplexed by SW1 and SW2. The  
25 signal de-multiplexed by SW2 is the signal generated by the reference transmitter (78), which has a direct light path to the receiver. The reference transmitter (78) is driven at a constant signal level. The signal from SW2 is compared with a reference voltage by an  
30 error amplifier (80). Negative feedback is applied via the low pass filter (72) to a gain control in the synchronous rectifier and so this control loop operates in such a way as to keep the signal at the output of the synchronous rectifier due to the

- 15 -

received reference transmitter signal substantially constant. The constant level is preset by the reference voltage on the error amplifier (80). In this way any changes in gain, e.g. an increase in gain, of the receiver are compensated for by a corresponding decrease in gain of the synchronous rectifier.

Thus the effective gain of the receiver circuit from the receiver all the way through to the output of the synchronous rectifier (64) is held constant. Therefore, any changes in the received signal level from the main transmitter must be due to changes in the actual received signal level at the receiver. This represents an inexpensive method of achieving accurate gain compensation.

An additional source of error in this kind of detector can be caused by changes in the ambient temperature causing variations in the transmitted power. Infra-red transmitters made from Gallium arsenide and Gallium aluminium arsenide have quite marked negative temperature co-efficients. The technique described above also provides compensation for these effects because the reference transmitter will exhibit a similar temperature characteristic to the main transmitters and so the appropriate receiver gain adjustment will be made automatically.

As a means to provide features 5) and 6) above the received and demodulated signal from the low pass filter (70) is fed to a subtractor (82). The output of the subtractor is a voltage representative of the received signal minus a variable offset

- 16 -

voltage. A comparator (84) indicates whether to increase or decrease the offset voltage. In this way the output of the subtractor (82) tends towards zero in the long term. Thus short term reductions in the received signal are detected by a comparator (86) provided that the reduction is greater than the threshold voltage presented to the comparator (non inverting input).

The output comparator (84) is connected to a bi-directional ramp generator (88) (integrator) and controls the ramp direction. For ease of description it will be assumed that comparator (84) is indicating that an increase in ramp voltage is required in order to bring the circuit into "balance".

Operation is as follows:

The ramp generator (88) ramps upwards towards a predefined limit which is set by the upper voltage threshold on a window comparator (90). If "balance" is not reached prior to the ramp voltage reaching the upper threshold then the window comparator (90) will trip causing,

25

1) SW3 to close providing hysteresis.

2) The ramp generator capacitor to be rapidly discharged until the ramp voltage falls below the upper threshold voltage of window comparator (90). The threshold is moved in response to step 1).

30

- 17 -

3) An 8 bit up/down counter (92) to increment its output count by one (N.B. ramp direction from comparator (84) indicates "up").

5                   4) An 8 bit D to A converter (94) to increase its output voltage by one LSB.

                  5) A clock pulse to appear on the clock input of an octal counter (96).

10

                  The ramp voltage is attenuated and added to the D to A output in such a proportion that the total ramp voltage excursion from zero to the upper threshold voltage of window comparator (90) is made slightly greater than the voltage step in the D to A output produced by one LSB change in the D to A input.

15

                  Given that the time required to discharge the ramp capacitor is very short compared to the ramp rate (of the order of 1:100), it can be seen that the output of a summation circuit (98) moves in essentially a ramp like manner. The finite resolution of the D to A converter acting in combination with the infinite resolution of the ramp generator provides an infinitely variable ramp voltage over an enormous range and at an accurately determinable rate of change. It would be virtually impossible to achieve this degree of performance over a wide temperature range with a capacitor based ramp generator alone and even if it were possible there would certainly be no cost or reliability benefit. The voltage tracking circuit described above has been operated over a +/- 8 volt ramp excursion range at 100 microvolts per second rate without resorting to any special circuit measures such as capacitor leakage compensation circuits etc.

20

25

30

- 18 -

Features 7 and 8 are provided as follows.

When detection of a person in the zone (20) has occurred the output of the comparator (86) is high and circuit (100) operates to open the doors. The signal  
5 at the reset of octal counter (96) is low. The counter (96) thus cycles through its count cycle. Signals appear sequentially on outputs Q1 to Q7 every say 20 to 30 seconds. When an output appears at Q7 the bi-directional ramp generator (88) is caused to  
10 assume its rapid ramp mode. This results in the circuit resetting so that the door opening signal is removed. It will be seen that an audio generator (102) and a loudspeaker (104) are connected to the Q6 pin of the octal counter (96). This means that a  
15 given time, e.g. 20 second before the reset, i.e. when the counter output is cycled to Q6, the loudspeaker is energised to provide a warning or alarm that the doors are about to close.

20 In the arrangement shown in Figure 2 a door opening signal is produced by the circuit 100 when the input to the comparator (86) from the circuit (82) is above the threshold level applied to the comparator. To provide a facility which enables the sensitivity of  
25 the circuit to change with for example changes in floor reflectivity the circuit (98) can be replaced by a multiplier. Alternatively the threshold level of the comparator can be made variable the variation being in accordance with variations in the output  
30 level of filter (70). In figure 2B this is achieved by connecting the input of the circuit (82) via a resistor (106) to the junction of a potential divider (108, 110). This potential divider generates the threshold level for the comparator (86). The effect

- 19 -

of this connection is to provide a threshold level which varies with variations with the input to the circuit (82) and hence varies the threshold in accordance with changes in, for example, floor reflectivity. The ability of the circuit to adjust the sensitivity in this way is considered to be an important aspect of the control circuitry.

Figure 3 shows a modified form of the detection arrangement of Figure 1. In cases where the floor in the vicinity of the sliding doors is highly absorbent of infra-red energy it is more likely that the illuminated horizontal surfaces of the object being detected will cause a counter productive increase in reflected energy. In such circumstances there is a possibility that this could lead to an object not being detected. Figure 3 shows an arrangement in which the angular spread of both the transmitter and receiver beams is such that the intersection of the beams is arranged to occur at approximately 20 inches above the floor. It will be appreciated that, for example, a child of height 2 feet would be easily detected since its horizontal surfaces would be unable to directly reflect energy from the transmitter to the receiver. The shoulders of the child would be in a shadow cast by its head in the instance that the child's shoulders were parallel to the plane of the floor. It should be noted that the figure of 20 inches is given simply as an example and it may be that a different point of intersection would be more appropriate in other applications. Because of the modified geometry of the beams of Figure 3 the detection zone (20) is shorter than that of Figure 1, when viewed in the direction parallel to

- 20 -

the plane of the door. As the detector circuitry described above is designed to detect a predetermined percentage change in the receiver signal, the detector of Figure 3 will be more sensitive to a given object than that of Figure 1.

Historically optical detectors have been unable to detect reliably objects such as empty wire-framed shopping carts. Because the detection zone shown in Figure 3 is more concentrated the detector is able more easily to detect such shopping carts. Experiments have shown that good results can be obtained when the detector circuit is set to detect percentage changes of the order of 5 to 10%. A further means of ensuring that all types of objects are detected is to arrange the circuitry to respond to both increases and decreases in signal level.

As explained in conjunction with Figure 1, in most installations there will be detection zones arranged on opposite sides of the door, so that objects lying directly in the path of the moving door and having a thickness greater than the perpendicular distance between the detection zones are detected. If the circuitry is designed to process signals from each detection zone independently then by looking at the relative timing of detection events in each zone it is possible to determine the direction of objects passing through the door. This can provide information which can be used to enhance operation of the door. For example, the redetection of a person by a motion sensor as he walks away from the door having passed through it could be eliminated by using the direction information. A further application could be in

- 21 -

estimating statistical parameters which may be of importance to management of the building in which the doors are used. The types of estimate that could be provided if all entrances and exits of the building are fitted with the device include the following:

- 1) Total number of people within a building with time.
- 2) Flow rates through the doors as a function of time.

The above description has been concerned principally with the use of the detector as a presence detector. It should be appreciated that the principles of the present detector can be used in motion detection. In motion detection changes in the received signal should ideally provide only momentary (of the order of one or two seconds) detection outputs sufficient to activate a door operating mechanism. This momentary detection can be provided by a simple high pass function as will be apparent to those skilled in the art. In the circuitry described above this can be achieved by increasing the voltage tracking rate by a suitable amount.

Furthermore, the range of the detector outwardly from the door needs to be increased to approximately 5 feet. This can be achieved by effectively tilting the detector away from the plane of the door. However, this may introduce variations in detection range under certain combinations of floor and clothing characteristics by virtue of the fact that reflection from the front vertical surface of an



- 22 -

object can now occur to a much greater extent. In other words reflection without obscuration has become possible by the change in geometric relationships.

5           An improved detection characteristic for motion sensing can be achieved by adopting the arrangement shown in Figure 3. The motion detection arrangement includes a transmitter (501) and a receiver (500) mounted as shown in Figure 3. It will be appreciated that these devices are additional to the transmitter and receiver arrangement which provide the presence detection. The transmitter (501) is configured to transmit two beams (506 and 507) to illuminate the floor in areas shown at (502 and 503).  
10           The receiver (500) is configured to receive energy along two beams (504 and 505) from the areas (502 and 503) respectively. The signals received by the receiver due to energy reflected from the areas (502 and 503) are measured separately to provide two  
15           signals L and R respectively. It should be noted that energy transmitted along beam (506) and received along beam (505) by way of reflection from an object must not corrupt the received signals. This condition can be achieved in a variety of ways including time  
20           division multiplexing or orthogonal modulation schemes. It will be seen that the received signal L is due exclusively to reflected energy from the transmitted beam (506) and in a similar manner the received signal R is due exclusively to reflected  
25           energy transmitted beam (507). Thus, it can be seen that the energy transference of transmitters to their respective receivers occurs almost exclusively by virtue of diffused reflection from the floor (that is to say as a result of an equal angle of incidence and  
30

- 23 -

reflections). An object approaching the door is detected when it interrupts any one of the transmitter/receiver beams. This motion will be detected by change in the level of the signals  
5 received at the receivers. In the case of presence within the areas (502 or 503) the presence will again be detected as changes in the reflected signals. The control circuitry necessary for processing such signals can be based upon a modified form of the  
10 circuitry described in detail with reference to Figure 2 and such changes will be apparent to those skilled in the art.

It should be noted that the motion detection  
15 profile associated with the detector can be made adjustable to enhance the operation of the detector. For example, the door could be made solely responsive to a detector pattern shown schematically in Figure 4. Figure 4 is a plan schematic view of the door area  
20 showing the zone covered by the detector/transmitter arrangement. Figure 4 also shows the mirror image (dotted lines) about the centre of the door. The arrangement can be achieved by making the detector respond to changes in only signal R or signal L as  
25 appropriate. This can be achieved by means of a simple selection switch within the detector.

Another detection pattern is shown in Figure  
4 and this can be achieved by responding only to a  
30 logical AND of the detection outputs due to the L and R signals or alternatively by a multiplication of signals representative of the signals L and R.

- 24 -

It should be noted that the detection pattern of the detector is dependent upon the height of the objects above the floor and the nature of this dependency can be controlled by the geometry of the transmitter and receiver beam cross sections and their directions. Detectors with very precise and desirable detection characteristics can be designed using the techniques described above.

Referring back to the presence detector described above, I have found that in some circumstances such a detector can be sensitive to wetting of the floor area in the operating zone of the detector. It is believed that this occurs because of strong specular reflections from the water surface and the floor. I have found that this problem can be alleviated or substantially eradicated if the transmitted and received beams are polarised in substantially orthogonal planes. Thus, I propose providing both the transmitter and receiver with a polariser which will plane polarise the radiation emitted by the transmitter and received by the receiver. The polarisers are arranged orthogonally so that, for example, the planar polarisation of the receiver polariser is at right angles to that of the transmitter. Any type of polariser can be employed, but a particularly suitable type has been found to be HR material as this has good performance in the near infra-red.

In the case of orthogonal polarisation, purely specular reflection is rejected and the effect on the received signal due to the presence of water is minimised to a level small enough so as not to be

- 25 -

detected. The automatic tracking facility provides sufficient compensation in this instance.

5           If the floor acts as a diffused reflector  
(which is true in most cases) the detector operates as  
has been described previously in that in most  
instances the presence of an object causes a signal  
drop. The fact that the detector circuitry is  
10       designed to detect a percentage drop in signal means  
that the sensitivity to a given object is not reduced  
by the attenuation produced by the exclusion of  
specular components from the floor or some of the  
background.

15           In some ways the detector response is  
improved in that the reflected signal from the floor  
is no longer dominated by the specular rich reflection  
components from the floor close the mid point between  
the transmitter and receiver units. This can result  
20       in a more even sensitivity profile along the length of  
the doorway.

          It is believed that the use of polarisers in  
particular cross polarisers is novel in the general  
25       field of proximity detectors and its use therefore is  
not considered restricted to the particular type of  
proximity detector described in this application.

- 26 -

CLAIMS:

1. A proximity detector comprising a  
5 transmitter for transmitting a beam or beams of  
radiation into a preselected area of zone or zones, a  
receiver for receiving radiation from that zone, the  
transmitter and receiver being spaced apart and so  
located relative to said zone that the transmitter  
10 transmits a beam of radiation of predetermined shape  
into the area from where it is reflected into the  
receiver, the relative dispositions of the transmitter  
and receiver being such that when an object is present  
in the zone a shadow is effectively cast on either  
15 side of the object to thereby cause a fall in the  
level of reflected radiation received at the receiver.

2. A detector according to claim 1 including  
control circuitry responsive to the received signals  
20 for providing an actuator signal or signals for  
controlling the operation of apparatus such as  
automatically operable doors.

3. A detector according to claim 2, wherein the  
25 control circuitry is arranged to provide an actuating  
signal in response to the presence of an object.

4. A detector according to claim 2, or claim 3  
wherein the control circuitry is arranged to provide an  
30 actuating signal in response to the motion of an  
object.

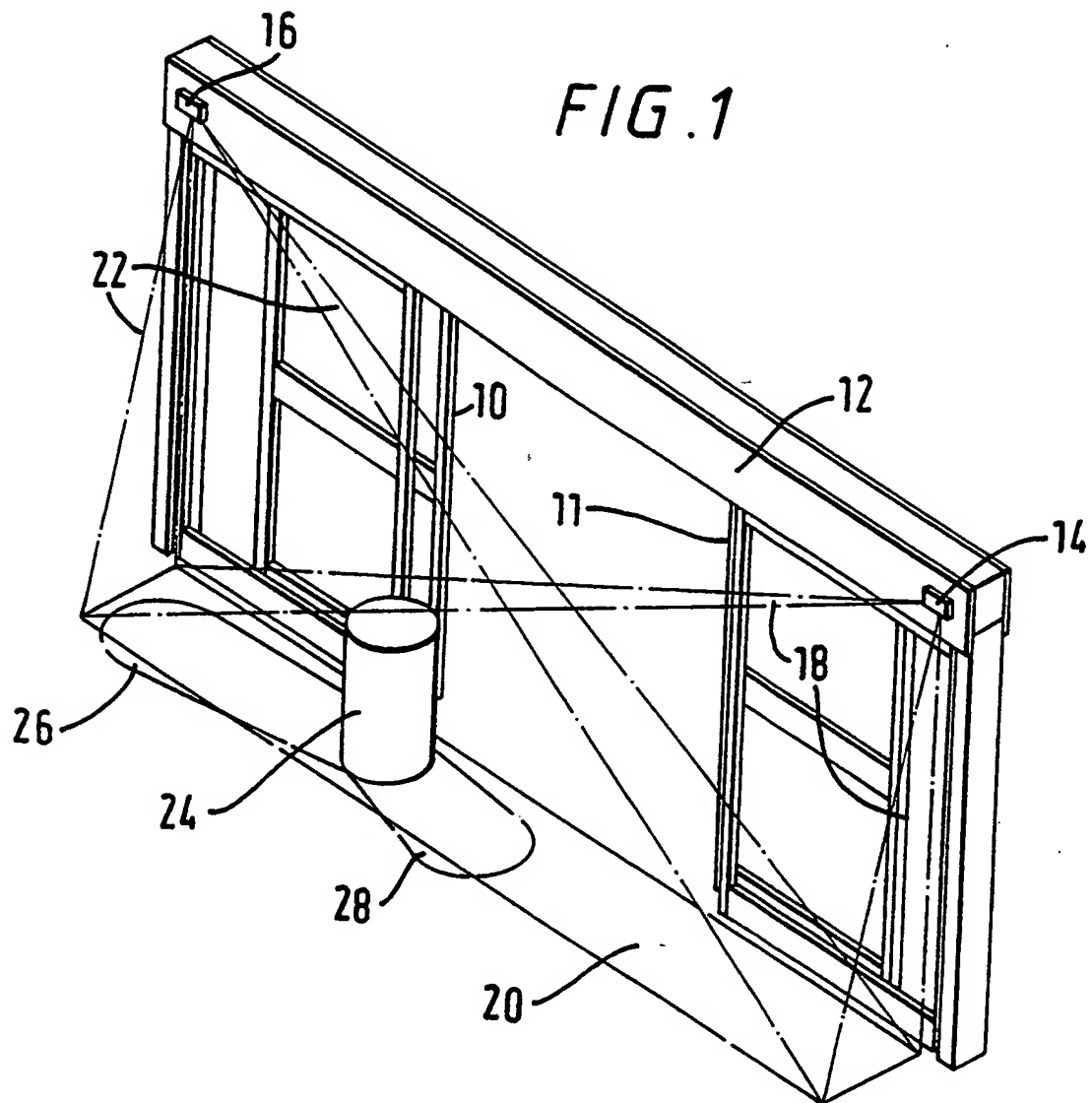
- 27 -

5. A detector according to claim 2, wherein the control circuitry includes means for avoiding interference between a plurality of similar detectors operating in close proximity to each other.
- 5
6. A detector according to claim 2 or claim 5, wherein the control circuitry includes means for providing immunity to interfering signals such as extraneous radiation from fluorescent lighting, radio signals or mains hum.
- 10
7. A detector according to claim 2 or claims 5 or 6, wherein the detector includes photodiodes and the control circuitry includes means for compensating effective changes in the sensitivity of the photodiodes.
- 15
8. A detector according to claim 2 or any one of claims 5 to 7, wherein the control circuitry includes means for compensating for temperature drift of the receiver or transmitter.
- 20
9. A detector according to claim 2 or any one of claims 5 to 8, wherein the control circuitry includes means for providing automatic adjustment to compensate for changes in background reflectivity levels.
- 25
10. A detector according to claim 2 or any one of claims 5 to 9, wherein the control circuitry provides a rapid reset facility in the event that an object is detected as being present for greater than a predetermined period of time.
- 30

- 28 -

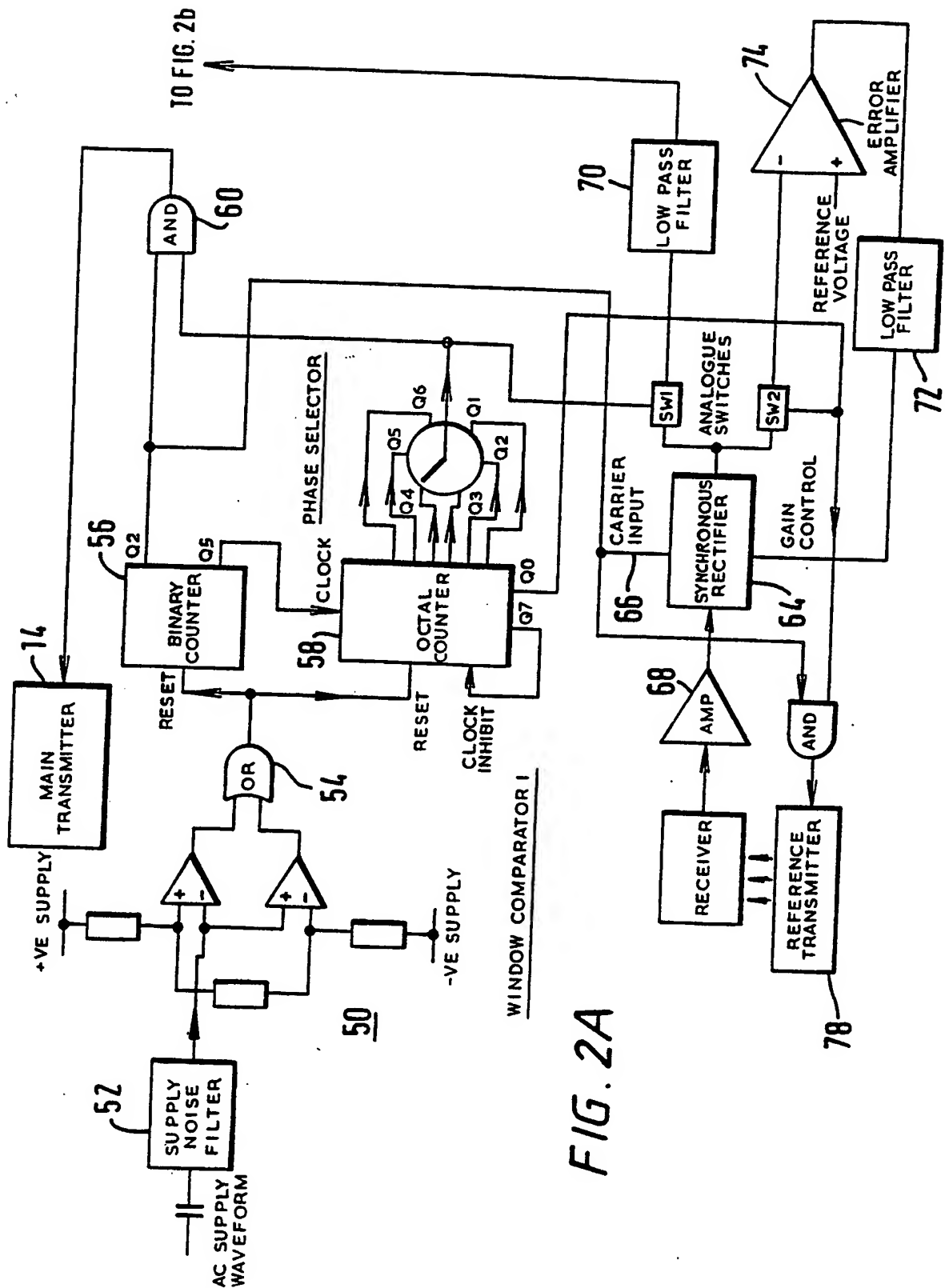
11. A detector according to claim 10, wherein the control circuitry includes means for providing an audible or visible alarm in the event that the object's presence for said predetermined time is detected.
- 5
12. A proximity detector of the type in which a transmitter transmits radiation into zone or zones and a receiver detects radiation receiver from the zone to provide actuating signals for actuating apparatus such as automatically operable doors, wherein a polarising means for polarising the radiation is associated with at least one of the transmitter and receiver.
- 10
13. A proximity detector according to claim 12, wherein a polarising means is associated with both the transmitter and receiver and said polarising means are arranged to function as a cross polariser.
- 15

1/5

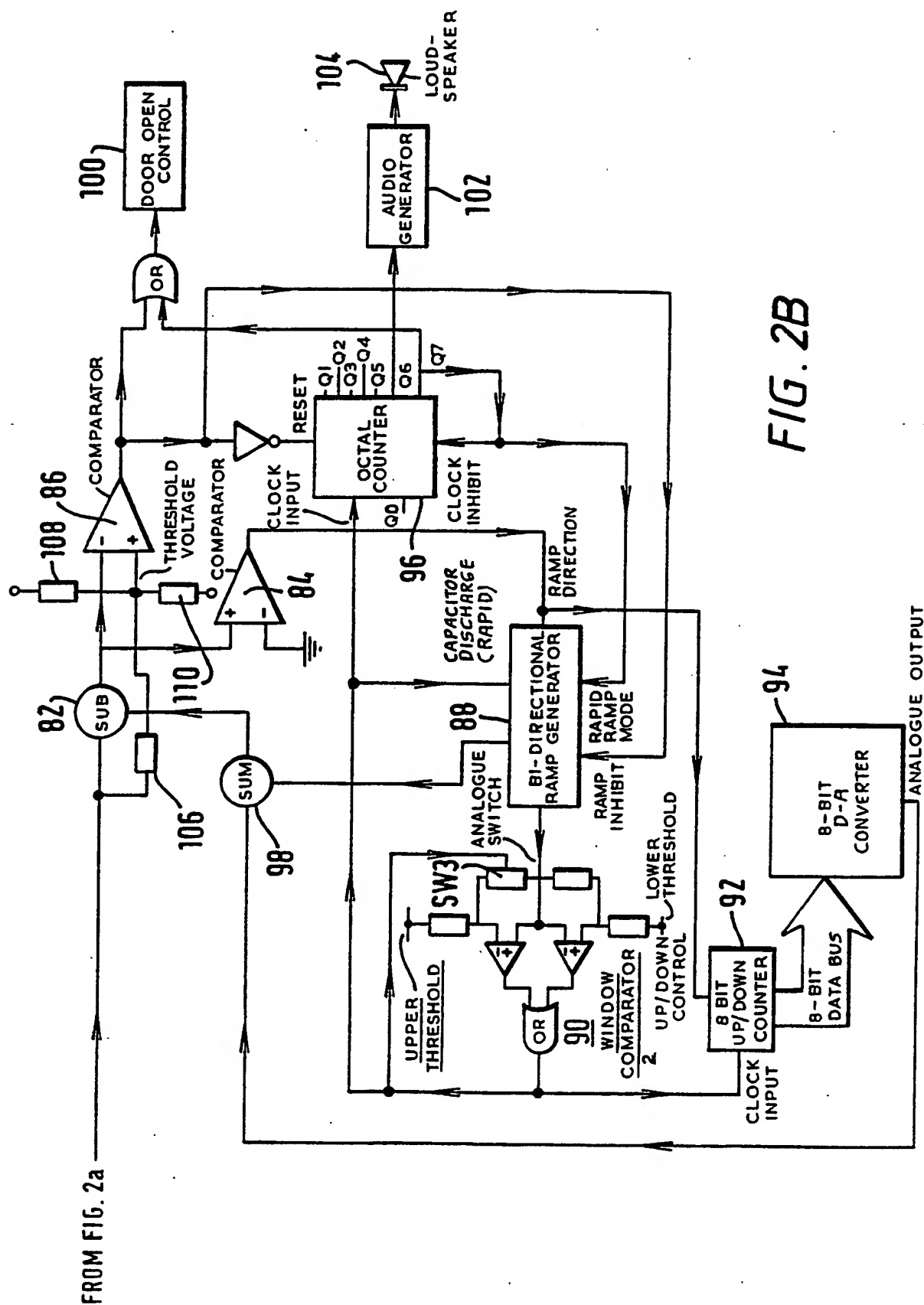




215

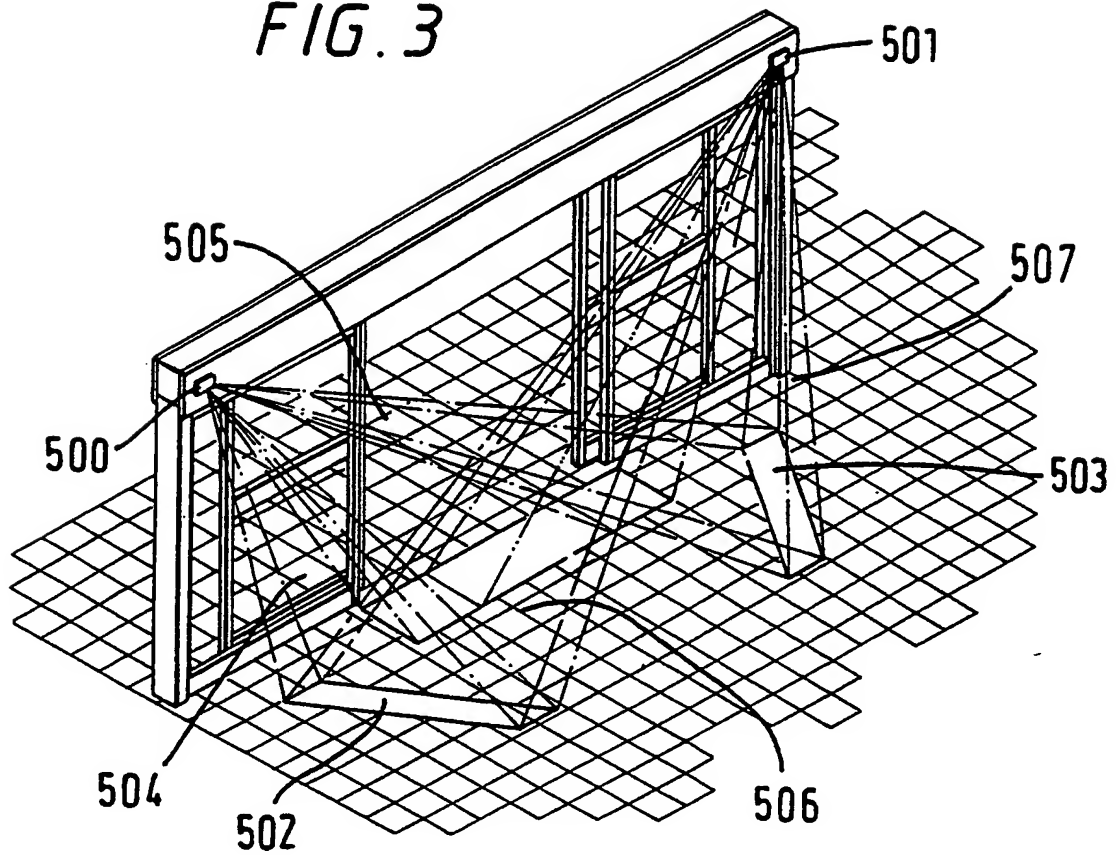


3/5



4/5

FIG. 3



5/5

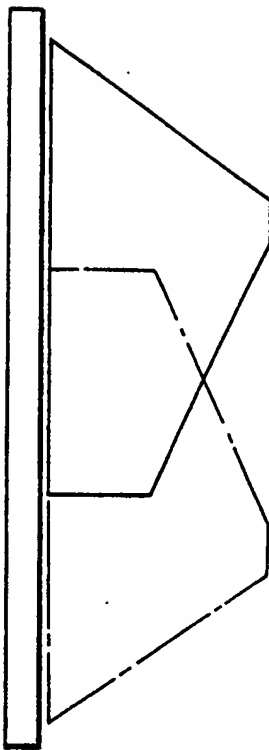


FIG. 4

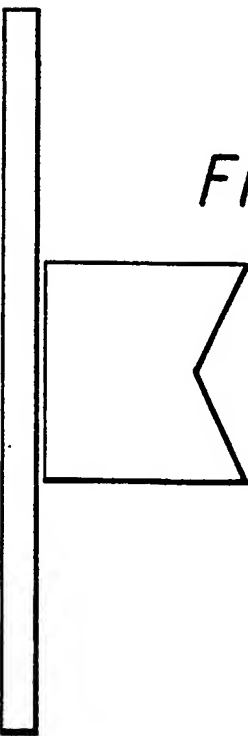


FIG. 5

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 94/02188

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 6 G01V8/12

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 G01V G08B F16P G08G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A,5 032 716 (LAM ET AL.) 16 July 1991  see abstract; figures 1,5 see column 1, line 21 - line 24 see column 1, line 54 - column 2, line 17 see column 2, line 66 - column 3, line 14 see column 3, line 27 - line 41 ---	1-6,12, 13
Y	PATENT ABSTRACTS OF JAPAN vol. 9, no. 58 (P-341) (1781) 14 March 1985 & JP,A,59 193 382 (SOUYOU KEIBI HOSHIYOU K.K.) 1 November 1984 see abstract ---	1-6,12, 13
Y	US,A,4 339 660 (BUCHHOLTZ ET AL.) 13 July 1982 see abstract; claims 1,2,4; figure ---	5,12,13
-/--		

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*&\* document member of the same patent family

Date of the actual completion of the international search

23 January 1995

Date of mailing of the international search report

1 0. 02. 95

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+ 31-70) 340-3016

Authorized officer

de Heering, P

# INTERNATIONAL SEARCH REPORT

Inter nal Application No

PCT/GB 94/02188

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A,5 012 086 (BARNARD) 30 April 1991 see abstract	6
A	<div style="text-align: center;">---</div> US,A,4 973 837 (BRADBEER) 27 November 1990 <div style="text-align: center;">-----</div>	

# INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/GB 94/02188

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-5032716	16-07-91	NONE	
US-A-4339660	13-07-82	NONE	
US-A-5012086	30-04-91	NONE	
US-A-4973837	27-11-90	AU-A- 7802887 WO-A- 8801394	08-03-88 25-02-88